Influence of Acoustic Tags on Susceptibility of Chinook Salmon to Predation

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Summary

As an ecosystem, the Sacramento-San Joaquin Delta (Delta) is unique as the largest estuary on the Pacific coast and home to more than 750 species of fauna and flora. About 40 native fish species inhabit the Sacramento-San Joaquin drainage with 17 endemics and a myriad of nonnative fishes (Moyle 2002). Human society uses the Delta extensively as a resource for recreation, water, industry, transportation, and other uses. Approximately two-thirds of all Californians, an estimated 23 million people, obtain at least some of their water from the Delta. This means the Delta is the single largest source of California's water. The water is diverted and transported by two primary pumping facilities: C.W. "Bill" Jones Pumping Plant and Harvey O. Banks Pumping Plant. Both sites are equipped with fish salvage facilities upstream of the pumping plants to reduce the number of fish entrained to the pumps and into the water deliveries. Both the federal Tracy Fish Collection Facility (TFCF) and the state Skinner Delta Fish Protective Facility use a behavioral type louver bypass system to guide fish out of the canal and into collection tanks where the salvaged fish are held and then transported and released back into the Delta.

Non-native predatory fishes inhabit the Sacramento-San Joaquin River Delta area in and near the TFCF (Reyes *et al*. 2007). Efficiency of the louvering systems to guide fish through each water pumping facility is negatively influenced by non-native predators residing near as well as within the facilities. These non-native predators directly influence salvage rates by consuming smaller fishes including threatened and endangered species such as juvenile Chinook salmon (*Oncorhynchus tshawytscha*), juvenile steelhead (*O. mykiss*), and adult and juvenile delta smelt (*Hypomesus transpacificus*).

Efforts to monitor, restore, and enhance the Delta's unique flora and fauna have been ongoing for years. Included in these efforts are well known cooperative monitoring and research programs such as Interagency Ecological Program and Bay-Delta Program (formerly CALFED). The Vernalis Adaptive Management Program (VAMP) is one such cooperative program and is a component of the San Joaquin River Agreement. Officially

initiated in 2000, VAMP is a large-scale, long-term (12-year), experimental management program designed to protect juvenile Chinook salmon migrating from the San Joaquin River through the Sacramento-San Joaquin Delta. The VAMP is also a scientific experiment to determine how salmon survival rates change in response to alterations in San Joaquin River flows and State Water Project/Central Valley Project exports with the installation of the Head of Old River Barrier (SJRGA 2010).

Acoustic telemetry technology is a widespread and proven tool to study juvenile salmon movements (McMichael *et al*. 2010). The VAMP program's use of acoustic telemetry technology is ongoing, however, the full power of this analytical tool is only realized if it is appropriately implemented and the results are properly analyzed and understood. There is evidence of a high degree of predation on acoustic-tagged juvenile salmon (DSP-RP 2010; Vogel 2010) which confounds analyses and interpretation of acoustic telemetry data. The circumstances causing predation remain unclear but the possible substandard condition of acoustic-tagged salmon is hypothesized as a possible contributing factor (DSP-RP 2010; Vogel 2010). Mesa (1994) reviewed the literature on predator-prey interactions in fishes where substandard prey were used as experimental groups and most research indicated that such prey were significantly more vulnerable to predation. Both DSP-RP (2010) and Vogel (2010) state the need to evaluate this factor and conduct predatory avoidance tests (Vogel 2010). Without this information, the validity of study results may be in question.

Predator load often builds to high levels in the secondary channel at TFCF. The secondary channel at TFCF provides an advantageous setting to test the influence of acoustic tags on the susceptibility of Chinook salmon to fish predation due to the following factors: (1) unlike most laboratory/tank studies it will facilitate the use of wild, unmolested predators exhibiting more natural behaviors; (2) the area is highly accessible to personnel but not the general public; (3) test fish can be acclimated and easily administered to the system; (4) test fish can be collected following experimentation, allowing for more accurate data with less estimation; (5) predators can also be collected following experimentation, allowing for more accurate data with less estimation; (6) waterflows are controllable; (7) environmental conditions are easily measured; (8) this study can work in concert with ongoing predator removal studies (Wu and Bridges 2009); (9) unlike most laboratory/tank studies, pre-experimental maintenance tasks (*e.g*., moving/handling, feeding, cleaning, disease care/prevention, etc.) are not required for the predator load. Information gathered will prove valuable to TFCF related studies employing acoustic tag technology, including evaluation of movement and predation of fishes within and near TFCF.

Problem Statement

It is unknown if acoustic-tagged Chinook salmon are consumed by predatory fishes in the Delta at a rate different than untagged salmon. The possible substandard condition of acoustic tagged salmon was mentioned by Vogel (2010) as a factor contributing to the suspected high level of predation upon tagged salmon. Information acquired in our study will assist researchers with evaluation and interpretation of data on survival and movement of Chinook salmon throughout the Central Valley of California, with probable application to other systems.

Goals and Hypotheses

Goals:

1. Determine if acoustic-tagged Chinook salmon in ongoing VAMP studies are consumed by predatory fishes in the Delta at a rate different than untagged salmon.

2. Determine if there are differences with respect to initial survival of acoustic-tagged Chinook salmon released at night or during the day.

Null Hypothesis:

1. There is no difference in the proportion of Chinook salmon surviving among treatments (no tag, sham-tag, inactive tag) exposed to the predator-loaded secondary channel at TFCF.

2. There is no difference in the proportion of Chinook salmon surviving during night and day releases exposed to the predator-loaded secondary channel at TFCF.

Materials and Methods

We will use a 2 × 3 design with light level (*i.e.*, diurnal and nocturnal) and treatment (*i.e.*, inactive acoustic tag, sham-tag [surgical process but no acoustic tag implanted], and control [no tag and surgical process]) as variables. Juvenile Chinook salmon will be randomly assigned to each treatment and light level. All salmon will receive partial fin clips to distinguish them from wild fish. Inactive acoustic tags will be implanted into Chinook salmon using the current surgical process employed by VAMP investigators. All other aspects, including strain and size of salmon used (hatchery produced), maintenance temperatures and feeding regime, post-surgery recovery time, acclimation to release site, and method of release, will match those currently used by VAMP investigators (SJRGA 2010). Work will take place during water temperature conditions similar to those experienced during historical VAMP releases.

Ten Chinook salmon from each treatment group will be administered to each of the four bypass tubes leading to the secondary channel at TFCF starting one hour past sunset. A pilot study will help determine if the chosen number of salmon per treatment is adequate to detect potential differences. Released Chinook salmon will be recovered as described in Bowen and DeMoyer (2009). Following a period of 2 d the same process described for nocturnal trials will be repeated at 1000 (diurnal trials). This process will be repeated until three nocturnal and diurnal trials are run, at which time fishes will be removed from the secondary channel and species and length recorded.

Data Analyses

We will use a 2 × 3 contingency table design and chi-square or Fisher's exact test to compare the expected contingency table to that observed. Multiple comparisons will be made using procedures referenced in Tanase and Matsuda (2006). A significance level of 0.05 will be used for all tests. Statistical analyses will be performed using JMP Statistical Software (SAS Institute Inc., Cary, NC).

Coordination and Collaboration

Study aspects will be coordinated with the Tracy Fish Facilities Improvement Program Manager, research coordinator, and the Tracy Series Editor. All experiments will be coordinated with the TFCF Fish Diversion Operators and TFCF Biology staff. Additional comments on design and implementation will be sought from staff at the Tracy Fish Collection Facility and Denver Technical Service Center, and other interested parties. Participation and inclusion of research-related modifications and updates will be provided to the Tracy Technical Advisory Team and/or the Central Valley Fish Facilities Review Team upon request. In addition, we will be working closely with the VAMP group. Agencies associated with VAMP include U.S. Bureau of Reclamation, California Department of Water Resources, U.S. Fish and Wildlife Service, California Department of Fish and Game, San Joaquin River Group Authority, and others.

Dissemination of Results (Deliverables and Outcomes)

The primary deliverables will be articles published in both the Tracy Volume Series and a peer-reviewed scientific journal. Technical updates will be provided to the Tracy Technical Advisory Team and the Central Valley Fish Facilities Review Team, along with posters and oral presentations given at scientific forums. Additionally, information gained during the study will assist TFCF related studies employing acoustic tag technology, including evaluation of movement and predation of fishes within and near TFCF.

Endangered Species Concerns

This study will not involve the use of wild endangered or threatened species. Hatchery-produced specimens of sensitive species will be sought and used when available.

Literature Cited

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